Space Weather Technical Forecast

Issued on Sunday, 10 December 2023 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further isolated M-flares likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with two M-flares, reaching a peak M2.3 at 10/0353 UTC from AR3511. This is the most active of ten sunspot regions on the disc, eight of which are numbered. AR3511 is a longitudinally wide region in the far southwest, and while this has exhibited a decaying trend, maintains sufficient complexity for the potential for similar flares. AR3513 approaching the central meridian in the northern hemisphere was the most developmental region, consolidating its leader spots, while there was some development of its intermediate region. No Earth-directed CMEs were observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed by ACE were near or at background, declining from around 400km/s to near 350km/s by the end of the period, with persistently below average density. Total Interplanetary Magnetic Field (IMF) Bt, was weak, below 5nT, while the north-south component varied between +4nT and -4nT. Phi angle was predominately negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-1).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux was mainly Moderate, but briefly High, peaking at 1130pfu at 09/1450UTC. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) on a slightly declining trend. The observation at 10/0000UTC was 5.03e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is forecast with a likelihood of further isolated M-flares, predominately from AR3511 in the southwest or AR3513 in the north-centre disc.

Solar Wind / Geomagnetic Activity: A weak CME may give a glancing interaction late on day 1 (10 Dec), however this is very low confidence. Otherwise, current background solar winds have the potential to become slightly elevated due to the onset of any fast wind arrival from CH77/+, or perhaps CH80/+. This is most likely day 1 into day 2 (10-11 Dec), as indicated in Enlil, however confidence is low due to the coronal holes being difficult to see, largely obscured in SDO imagery. Any enhancement is likely to ease on days 3-4 (12-13 Dec). Quiet geomagnetic activity is forecast to become Unsettled with a spell of Active from any CME enhancement, along with a slight chance of G1 Minor Storm intervals, mainly later day 1 or early day 2 (10-11 Dec). Activity then easing to be mainly Quiet with isolated Unsettled intervals from late day 2 onward.

Energetic Particles / Solar Radiation: GOES16 high energy proton is expected to persist at background levels, with only a very slight chance of rising towards the S1 Minor Radiation Storm level given any significant flares from AR3511 or perhaps AR3513. High energy electron flux is expected to be mainly Moderate, briefly High, at first but dropping out with any CH or CME enhancements later day 1 or day 2 (10-11 Dec), before recovering to mainly Moderate levels later in the period. The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

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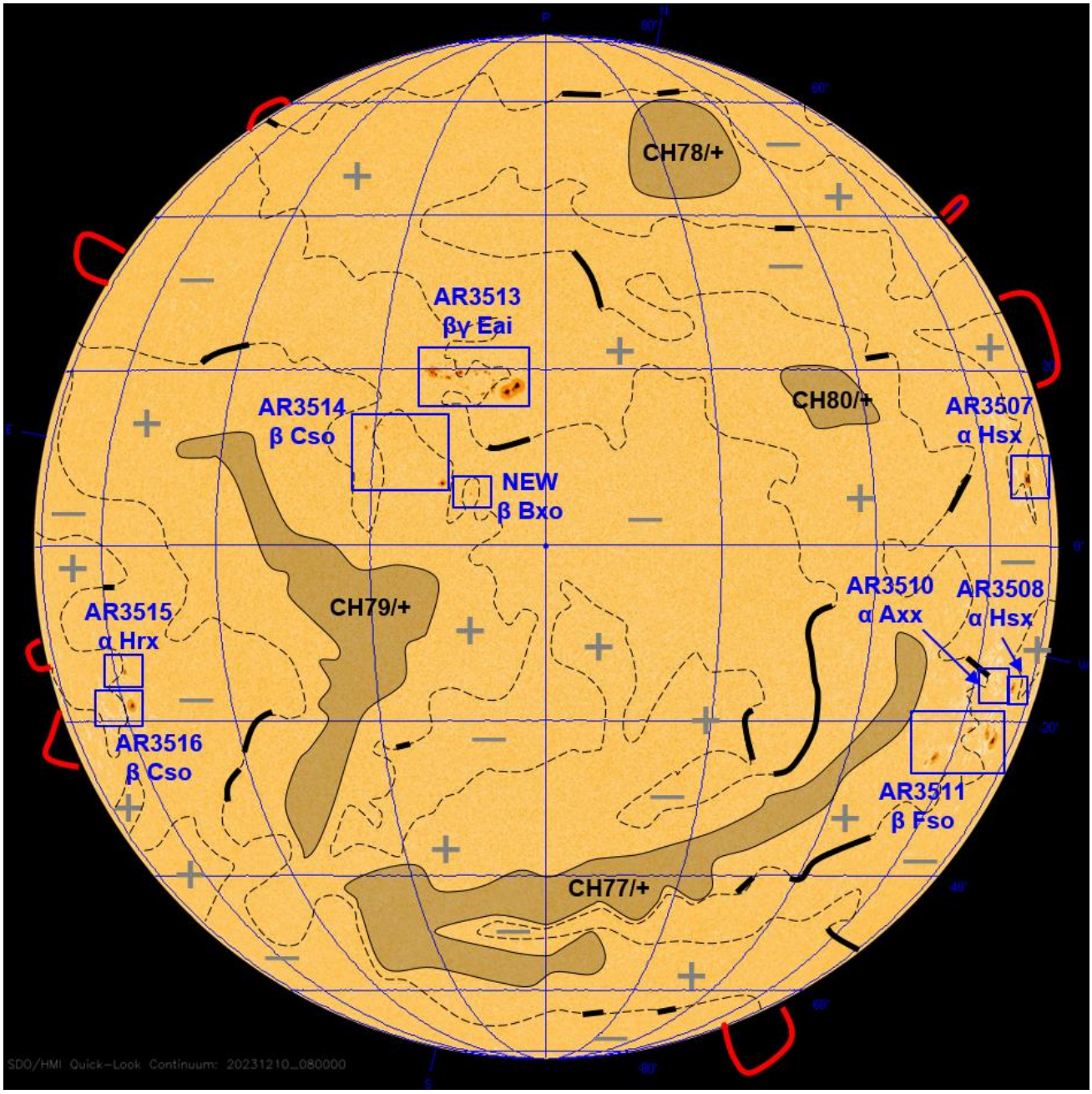
Figure 1. Solar Analysis Valid 10/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs that are expected to have a significant influence on geomagnetic conditions, however there is a low confidence glancing impact possible late on day 1(10 Dec) from a CME which left the northeast disc due to a filament eruption around 07/0200 UTC.

This CME may arrive alongside a weak enhancement from the southern coronal hole CH77/+, currently forecast for later day 1 (10 Dec). This is a narrow feature that is becoming hard to see amongst other coronal loops in SDO aia-imagery, but was clear in the southern centre disc on 07 Dec. There is also the very small and largely obscured CH80/+ in the northwest disc. This was observed opening in SDO aia imagery on 08 Dec, and quickly underwent morphological changes. While now very hard to see, it is aligned with CH77/+ longitudinally, perhaps increasing the potential for Earth to see some aspect of fast wind enhancement occurring. This enhancement is indicated in enlil solar winds, however due to the obscured nature of the coronal holes confidence remains low.

Current background winds are likely to increase to become slightly elevated to elevated (450-500 km/s) beginning late day 1 and continuing into day 2 (10-11 Dec). At the onset of this change, Quiet geomagnetic activity should increase to become Unsettled with Active intervals, and a very slight chance of peak G1 Minor Storm conditions occurring. Activity then easing to become mainly Quiet, with only isolated Unsettled intervals from late day 2 onward (11 Dec), as solar winds slowly ease back towards background by the end of day 4 (13 Dec).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
07/1302	Nil	Filament eruption	NE	406 km/s	Late 10 Dec	Very low confidence. Glancing impact at most.

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Figure 2a: Enlil showing fast wind onset from CH77/+ and/or CH80/+, and possible weak CME glance.

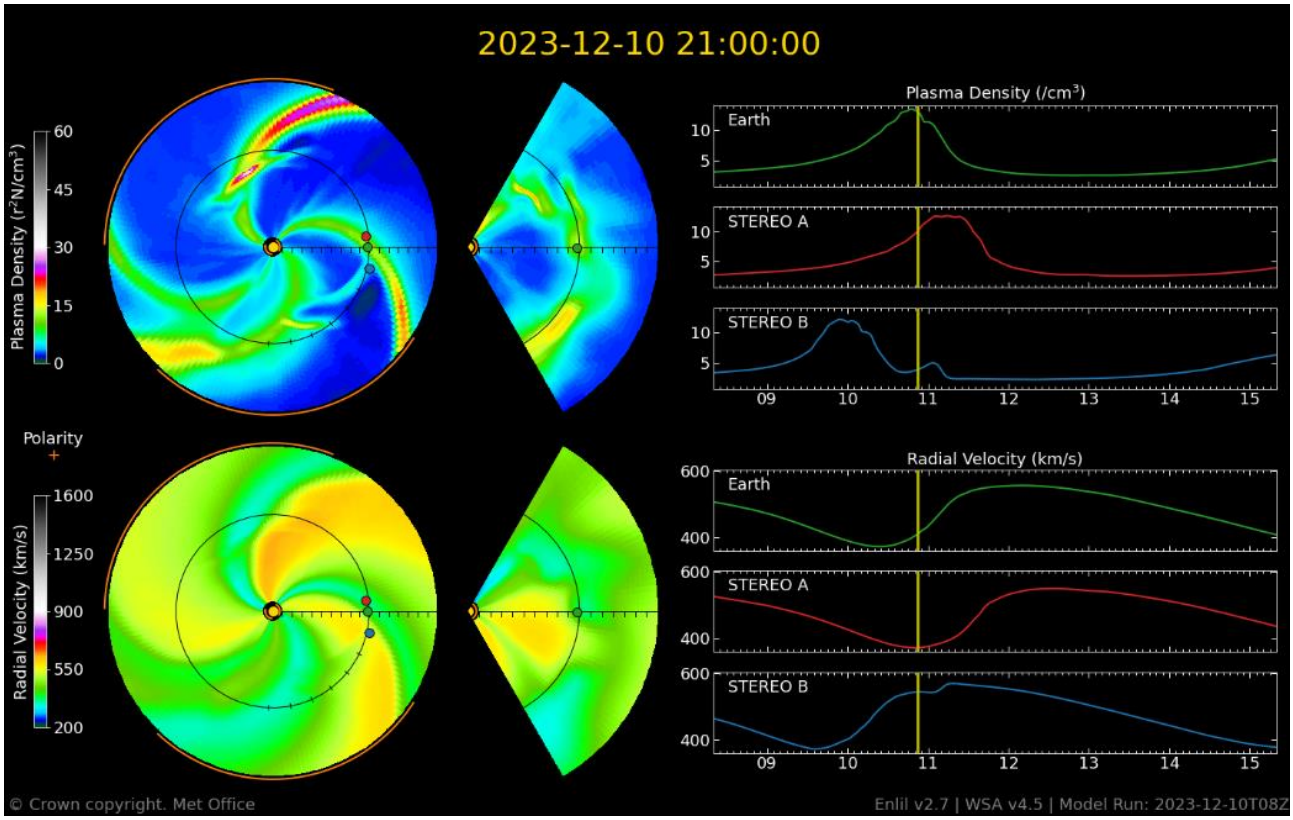
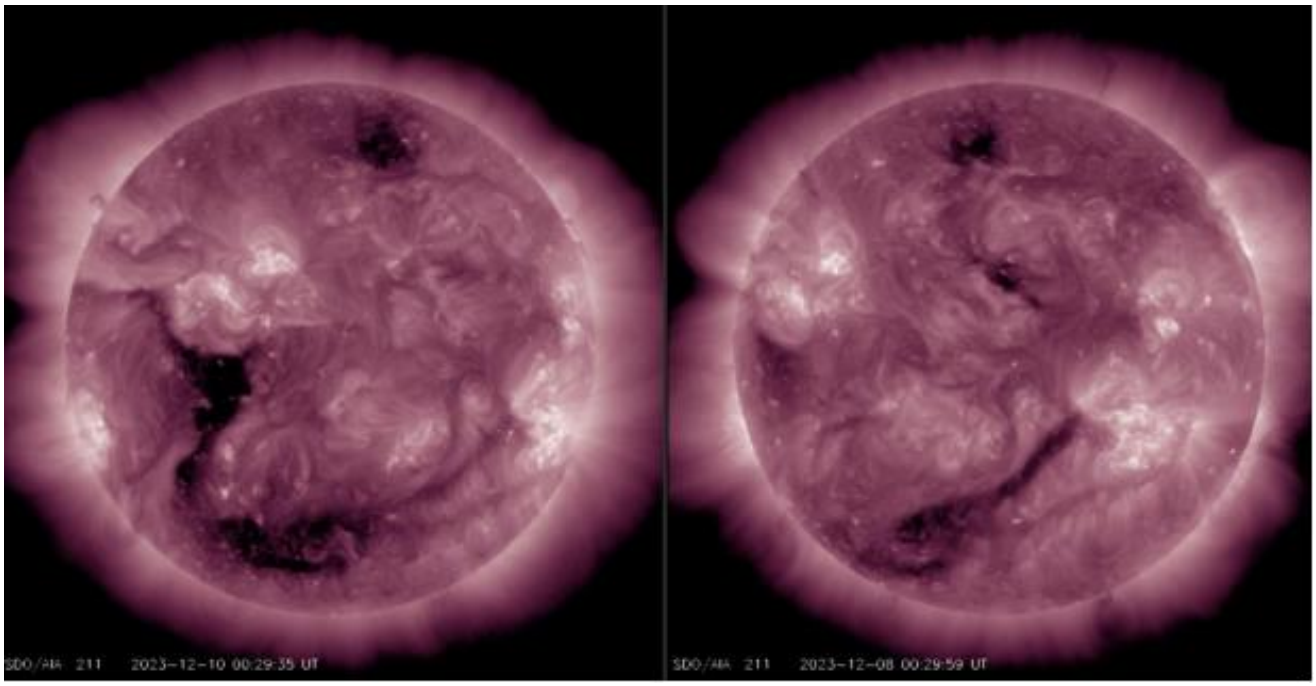


Figure 2b. SDO aia 211 current (left) and on 08 Dec (right). CH77/CH80 were more visible when in centre disc, but now more difficult to make out due to narrow/small nature of the coronal holes and surrounding coronal loops.



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Radio Blackouts - X-Ray Flares:

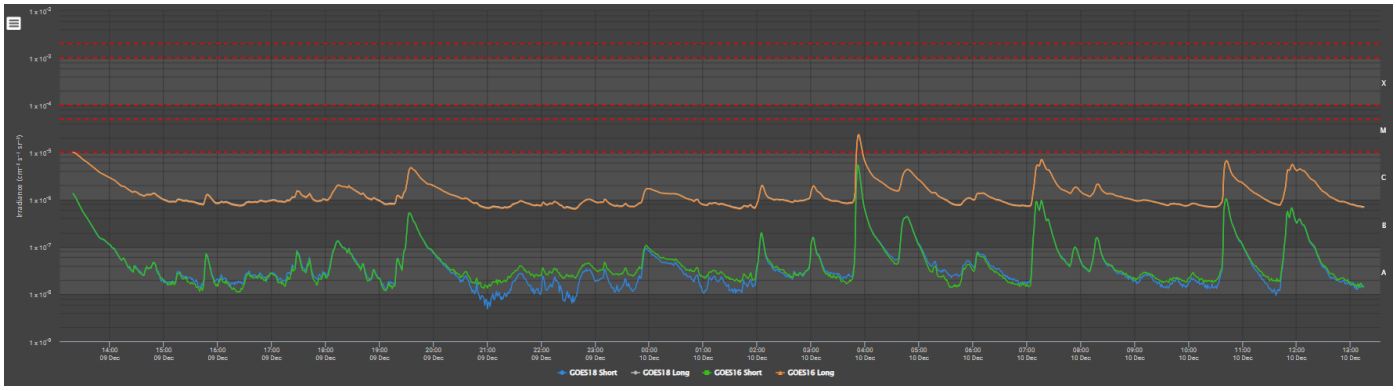
Low to Moderate activity is expected to continue with a likelihood of further isolated M-flares.

Of the ten sunspot regions on the disc, the main flaring risk is from AR3511, now approaching the southwest limb and AR3513 nearing the north-centre disc. AR3511 is longitudinally wide but also relatively small in areal extent, and was the source of recent M-flaring during the last 36-48 hours, due to the development of at least one delta spot. The main delta spot appears has subsequently faded, however there remains a very small potential delta amongst its intermediate spots near the main leader, although due to the regions proximity to the limb this is becoming harder to observe. Further M-flaring is possible from this spot. AR3513, while less active, is also moderately sized and has shown the most growth on the disc. There has been consolidation of its leader spots and the emergence of a number of intermediate spots of mixed polarity. Further growth could have a destabilising effect, also bringing a risk of M-flares.

The other regions on the disc are generally small, simpler and currently either stable or showing signs of decay.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	55	50	45
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: Latest GOES16/18 X-ray flux



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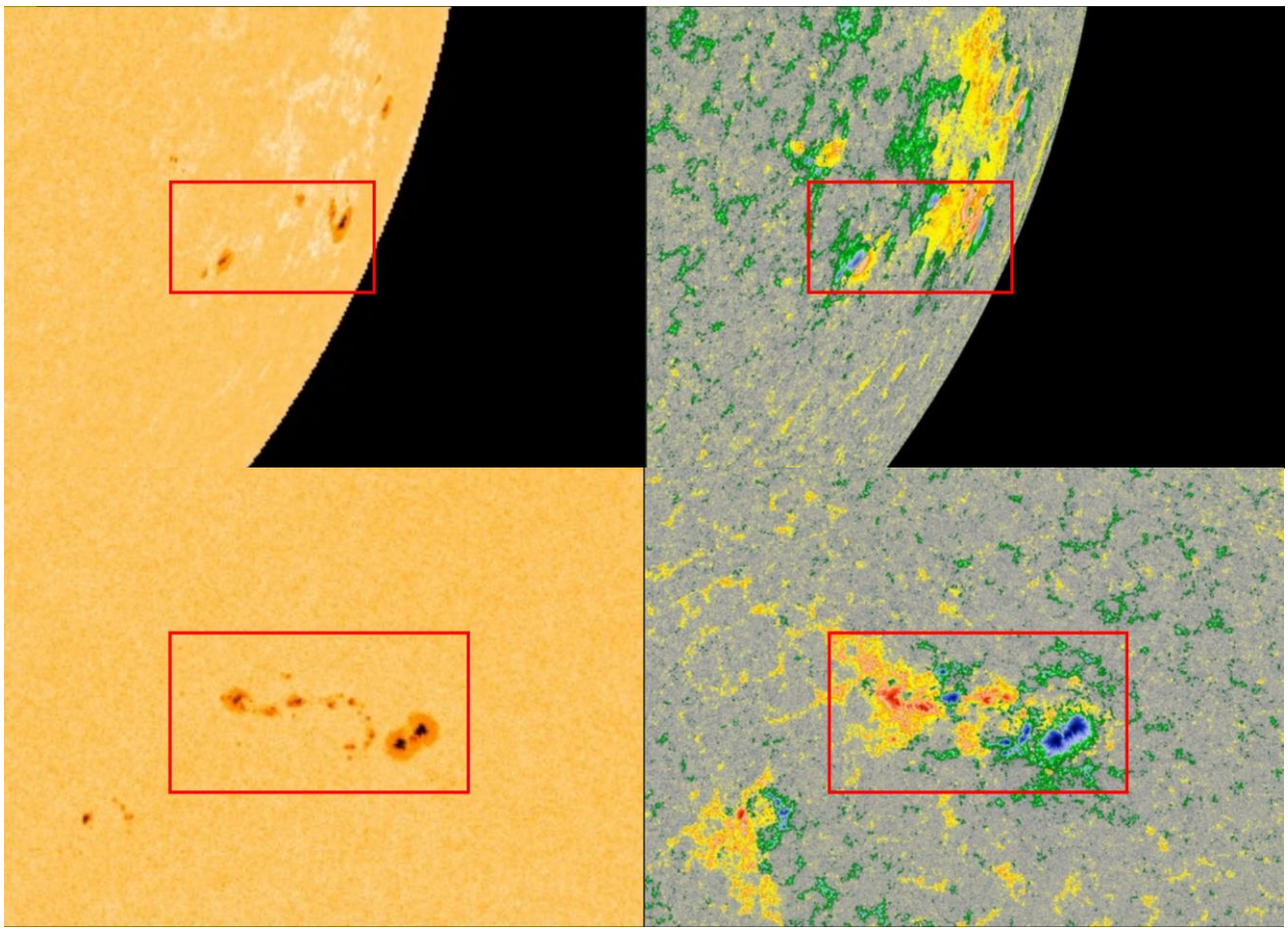
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background. There is a slight chance of this increasing given the occurrence of any further significant flares on the disc, especially from AR3511 in the far southwest, and also from AR3513 if any further development occurs as it moves into the western hemisphere. However, this only brings a very slight chance of reaching the S1 Minor Radiation Storm level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	10	10	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO intensitygram and magnetogram of AR3511 (top) and AR3515 (below)



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16, has been mainly Moderate with only brief diurnal peaks at High, since the solar wind enhancement from a recent CH. This is expected to persist at first day 1 (10 Dec), before dropping more persistently to background with any subsequent enhancements from either CH77/+ or CH80/+, along with any CME glance that may occur later on day 1, or on day 2 (10-11 Dec). Some recovery in flux, to mainly Moderate levels, is then likely day 3-4 (12-13 Dec), with a slight chance of peaking at High levels.

The associated 24 hour fluence is expected to remain below the Active threshold through the period. This is supported by REFM, with the initial declining fluence likely, but with a chance of then rising days 3-4 (12-13 Dec).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES16 >2MeV Electron Flux and Fluence with REFM

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